An economic modeling of the foreseen restructured European Gas market

work in progress, submitted for discussion purpose only

Yves Smeers

CORE, UCL, Louvain la Neuve, Belgium

Séminaire d'Economie d'Energie, Université Paris Dauphine

10 April, 2013

This is joint work with Jacqueline Boucher, Andreas Ehrenmann and Guillaume Erbs;
Center of Expertise for Economic Modeling and Studies, GDF-SUEZ

The ideas submitted here evolving and may not reflect the final analysis of the authors.

Problem statement

Tensions in today European gas market.

- A European gas bubble started in 2008 because of:
  - decreasing demand due to the economic crisis,
  - increased supply due to non conventional gas in the US, leading to a reduction of LNG imports by that country
  - the globalization of the gas market due to LNG trade, which redirected part of US bound LNG to Europe.
- This resulted in two pricing mechanisms in the European market:
  - spot pricing (the short term price determined on European hubs),
  - prices determined by price indexation in long-term contracts.

The bubble forces long term contracts to operate outside of their design perimeters.

- Because spot gas in a bubble is cheaper than long-term contracted gas, mid-streamers find it difficult to sell their contracted TOP volumes at contracted indexed prices. They must
  - either violate TOP obligations and pay penalties,
  - sell part of TOP quantities at spot price,
  - dump some TOP quantities to the spot market.
- This creates direct losses for mid-streamers and indirect pressure on the producers to revise the contracts.
- Similar situations have been seen in the past:
  - The US pipelines could not sell their excess TOP gas in the eighties. This led to a full overhaul of the market and the elimination of the long term TOP contracts (Makholm (2012) gives an in depth institutional analysis).
  - British gas in the UK encountered a similar problem in the nineties. This led to a renegotiation of the long term contracts and the decline of their role (Stoppard 1997).

The pressure on the mid streamers and producers to "do something"

- This can be many things:
- Get out of the problem through regulation and litigation.
  - e.g. the US restructuring and to a smaller extent the UK restructuring.
- Move upstream.
  - Non conventional gas shows that "the sky is the limit" (IEA 2012 about North American demand)
- Resort more frequently to arbitration to re-open pricing clauses.
  - More frequent these days
- Redesign the contracts and develop a hybrid market based on spot and long-term contracts
  - Work on the structure of price indexation and TOP clauses (a technical approach to the problem)

These questions must be raised in a more global context: will we still have long term contracts?

- The other driving force: the restructuring of the European gas market.
- Possibly less fashionable than the restructuring of electricity, but not less significant (a bigger jump in the unknown, at least before the introduction of the roadmap to decarbonization!)
- Following up on a reasoning initiated by the 2005-2007 Sector Inquiry, restructuring places a strong emphasis on short-term competition:
  - the Gas Target Model initiated in 2011(inspired by "Market Coupling" in electricity)
  - whose implementation since nurtures the work of the "Madrid Forum"
  - while remaining remarkably silent on the substance of long term contracts!

The spirit of the restructuring (CEER 2011).

- The restructured system: "In their approach, regulators see a competitive European gas market as a combination of entry-exit zones with virtual hubs. Their vision suggests that the development of competition should be based on the development of liquid hubs across Europe at which gas can be traded (these may be national or cross border). Market integration should be served by efficient use of infrastructures, allowing market players to freely ship gas between market areas and respond to price signals to help gas flowing to where it is valued most. The target model has to allow for sufficient and efficient levels of infrastructure investment, in particular where physical congestions hinder market integration".

The practice of the restructuring: market design through grid codes

- e.g. 2-3 October 2012 Madrid Forum: meeting agenda.
  - transit contracts (getting rid of special clauses in transit contracts),
  - (grid) capacity allocation mechanisms,
  - balancing,
  - interoperability,
  - storage (transparency problems),
  - Gas Target Model (incremental investment in the grid),
  - other subjects unrelated to long-term contracts.

A view on long-term contracts (CEER 2011)?

- The traditional system: ”In many European countries, security of supply has been historically met through long-term contractual arrangements (typically 25 years) between gas producers and buyers, which give gas buyers flexibility above an agreed minimum in the volume of gas that will be redelivered within a contract year. These contracts include take or pay obligations, meaning that European gas buyers must take or pay for the minimum agreed volumes of gas. The long term gas contracts have also been seen as a key mechanism to underpin the investment in long distance pipelines and in gas production by sharing risks between gas producers and those investing. They remain important not only in guaranteeing security of supply but also in underpinning the investment in long distance pipelines and in gas production. They have been seen as a key tool for sharing risks between gas suppliers and those investing.”

Should we bother about long term contracts?

Possible responses

- No!
  - Look at the US and UK where ”long term” today means two to five years; contracts are essentially financials and the old TOP clauses no longer play a significant role.
- Maybe!
  - There is a whole literature on the relevance of long term physical contracts (starting with Hubbard and Weiner 1986 and 1991), we might be in one of the relevant situations. The literature is rooted in transaction costs and justifies bilateral negotiations for at least two reasons:
    - Risk sharing through physical vs financial contracts: related to the structure of the price indexation and TOP clauses; not discussed here.
    - Market power that implies some bargaining between producer and buyer. No market power problem in today US gas market (see Makholm 2012); not much mentioned in the UK so far (but the UK is also becoming more and more an importer!). Could that be relevant for the EU?
  - See Glachant Hallack (undated) and the book edited by Brousseau and Glachant (2002) for further developments on the literature on bargaining and contracts.

Market power in the upstream European market

- Go back to the the Sector Inquiry (EC 2007)
  - No concern about upstream market power; concern about downstream market power and violation of competition law.
  - The literature on the restructuring of the EU gas market follows suit: no mention of upstream market power in Moselle White (2011), Ascari (2011), Frontier Economics (2011). Only CIEP 2011 mentions upstream market power.
- This benign attitude with respect to upstream market power contrasts with:
  - concern on external dependence of gas supply (EC), economic literature on EU gas market (mainly academic), concern on security of supply (academic and policy); EC action in favor of special projects aimed at reducing external dependence; very recently proceedings of DG COMP against indexation clauses in contracts by upstream companies (that in principle should have no market power if there is no upstream market power!)

Is this a fault of logic and if so is there an explanation?

- Difficult to say for sure. But one can submit the following:
  - Actions on the downstream and upstream market power may have different effects.
  - But it is difficult (impossible when dealing with market design) for the EC to act on upstream market power.
  - It is then formally and politically more convenient (but logically flawed) to take up upstream market power as a problem of security of supply and not mention it anymore in the market design for natural gas.
- Suppose one admits that upstream security of supply concern cannot exist without upstream market power. Then we need to look at the impact of the development of the hub system foreseen by the restructuring under the assumption of upstream market power.

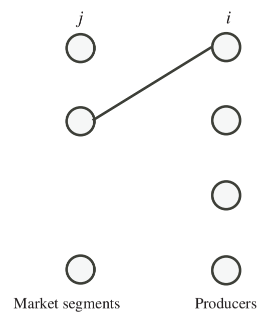
A more familiar restatement of the question in “second best” terms

- Does it help to make the downstream competitive if the upstream is not competitive?
  - A non competitive downstream market is a market failure.
  - Does it always help to remedy a market failure in the presence of other markets failures (here upstream market power)?
- There is a general ”second best principle” that responds negatively.
- It is thus useful to assess the impact of the removal of downstream market power in the presence of upstream market power.

A modeling approach

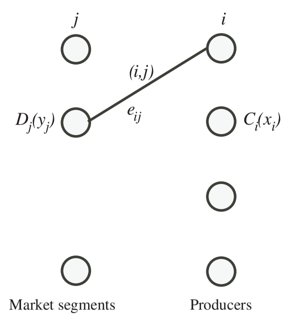
A modeling approach: a schematic description of the market

A stylized model: a bipartite graph with producers and mid-streamers



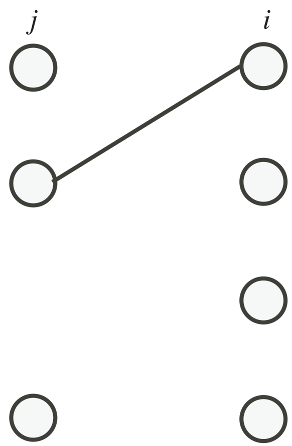
- The traditional market
  - One mid-streamer per market segment.
  - Producers and mid-streamers have market power and engage in bilateral negotiations.
- The new market (given upstream market power)
  - Producers set the price at which they sell to mid-streamers.
  - Several mid-streamers in competition, taking price from the producers as given.

A stylized model: model data



- $D_j(y_j)$: inverted demand of market (segment) j
- $C_i(x_i)$: cost function of producer i
- $e_{i,j}$: transport cost
- everything is meant to be annual and long-term

The traditional and new markets



- <u>Traditional market and contracts:</u>
  p_{ij} price charged by producer i to mid-streamer j (price clause) for a quantity q_{ij} (TOP clause).
  One mid-streamer per market segment.
- <u>New market and hub pricing:</u>
  p_j price on hub j for quantity $\sum_i q_{ij}$.
  Several mid-streamers per virtual hub.

A modeling approach: pricing paradigms

Two pricing mechanisms

- Market Value pricing (”Anlegbarkeit” in the old days):
  - What the market can bear! (goes back to the first Dutch contracts)
  - Underlies pricing clauses in long-term contracts
  - that have disappeared in the US and UK.
  - and that many argue should also disappear in the EU on the basis of an argument of linkage to oil products (see in particular Stern 2007 and 2009 and Stern and Rogers 2011).
  - For our purpose, Anlegbarkeit is ”first order” price discrimination in standard monopoly models.
- Hub pricing:
  - Gas to gas competition
  - Decoupling from the ”competing fuel”.
  - Physical hub in the US, virtual hub in the UK, towards virtual hubs in EU with some remaining physical hubs.

Properties of Market Value Pricing (1)

- Market Value pricing was justified before as necessary to (almost) guarantee that mid-streamers could sell TOP contracted quantities.
  - One can argue (e.g. Lapuerta 2012) that this is no longer necessary if excess gas can be dumped on an exchange. Gazprom 2013 argues that indexation and TOP clauses make long term contracted gas a product different from gas traded on the spot market. One can also argue that a long term contract is a agreement on a price and a quantity in contract theory, or can also be interpreted as a non linear price. Transactions on the spot market are driven by linear prices. There are thus differences, the question is whether they have an impact. This is what we want to explore.
  - It is also argued that fuel substitution possibilities have drastically decreased and that market value pricing is no longer applicable. This may be true in the short-term. The true test is the empirical relation that one could find between gas and oil products in markets that have run without index action clauses for several years.

Properties of Market Value Pricing (2)

- The following property was often mentioned before but seems to have been forgotten today
  - Market Value Pricing captures the whole welfare of the system even when there is market power.
  - Market value pricing is thus economically efficient.
- But one certainly remembers that
  - Market Value Pricing is discriminatory (it prices gas essentially depending on its use)
  - with legal proceedings against this clause now underway in Germany (at the mid-stream level) and the EU (at producer level).

Properties of hub prices

- Hub prices:
  - clear the market at the hub.
    - Producers deliver at the hub and mid-streamers buy at the hub in the restructured system.
    - Hub prices thus depend on the market power at the hub.
    - They also depend on the liquidity of the market (see current discussions comparing HH, NBP and other European hubs).
    - GTM, which underpins the current work of the Madrid Forum, foresees a HHI of mid-streamers below 2000 and at least 3 different sources of total gas competing at the hub.
  - are by construction non discriminatory.

A modeling approach: modeling paradigms

Market power and Non cooperative games

- Some paradigms have become common in the restructuring literature.
  - Perfect competition is the counterfactual of reference.
  - Cournot oligopoly of producers with competitive downstream is also standard.
  - Cournot producers and Cournot mid-streamers or monopolies are also possible descriptions of the traditional European gas market (Boots et al. 2004 and Holz et al. 2008).
  - There are also models with competitive upstream and Cournot Mid-streamers (Egging and Gabriel and other coauthors (e.g. Massol and coauthors) in many papers in the last five years)
- Other paradigms are less usual but may offer better representations or give additional insight on the traditional and new worlds. We consider
  - bilateral negotiation with market value pricing in the traditional market;
  - bilateral negotiation with hub pricing for the new market.

A modeling approach: perfect competition and standard Cournot based model

Perfect Competition

- Simulates a market where upstream and downstream market power has been eliminated.
  - The natural interpretation is physical hub pricing with competitive upstream and downstream and capacitated point to point transportation.
  - Can be modified to represent entry-exit and virtual hub at the cost of data manipulation.
  - Could thus be used to represent the outcome of the restructuring under the assumption that there is no upstream market power. We do not consider that case.
  - Easy to solve and interpret in terms of netback,
  - but unable to the represent price discrimination (different netback at a node depending on destination point) in long term contracts.
- Will be used here as a computational device (not as a true market representation) for assessing the outcome of bilateral negotiation with market value pricing (see below).

Cournot model.

- Simulates a market with upstream market power and competitive downstream.
  - Each producer selects quantities to deliver to individual market segments in order to maximize its profit taking into account the quantities delivered by the others to these market segments.
  - This is compatible with hub pricing after the combination of restructuring and application of competition law has eliminated the market power of mid-streamers.
  - Easy to solve and interpret in terms of exercise of market power (margin taken by the producers with respect to their marginal cost).There is price discrimination among market segments in the sense that the margin made by a producer can differ by market segment.
  - The model could also be considered as one where producers have absorbed/merged with mid-streamers in order to sell to the final consumers. This would allow for price discrimination among market segments. This assumptions is realistic (and foreseen by standard industrial economic theory (e.g. Tirole 1998)) but goes beyond our scope.

Nested Cournot models: upstream Cournot and downstream monopoly.

- Simulates a market with upstream and downstream market power.
  - Each mid-streamer behaves as a monopoly in its market segment for given gas procurement prices. This gives its derived demand function. Producers then behave a la Cournot with respect to the mid-streamers.
  - This is formally compatible with the traditional system as it assumes that both the producers and mid-streamers exercise market power with respect to their consumers. But it does not account for the bargaining power of the mid-streamer with respect to the producer; numeral experiments must decide whether its can effectively represent the traditional system.
  - The model is also formally compatible with the hub pricing but unrealistic as it assumes that the combination of the restructuring and competition law could not organize hubs with several mid-streamers in competition. Not considered here.
  - The model is relatively easy to solve and interpret in terms of upstream and downstream market power (margin by producers and mid-streamer).

Nested Cournot models: upstream Cournot and downstream oligopolies.

- Simulates a market with upstream and downstream market power.
  - A set of mid-streamers behave a la Cournot in their market segment, taking gas price from the producer as given. This results in a derived demand function by the set of these mid-streamers of that market segment. Producers then behave la Cournot with respect to these blocs of mid-streamers and their demand functions.
  - This is formally compatible with hub pricing where the combination of the grid codes and the application of competition law has largely eliminated the market power of the mid-streamers. The formulation with several identical mid-streamers in each market segment (ideal case with lowest HHI) but no cross border trade between the market segments makes the model relatively easy to solve and interpret in terms of upstream and downstream market power (margin taken by producers and oligopoly mid-streamers).

A sample of uses of these models in the literature

- Perfect competition Beltramo, Manne Weyant 1986; Boucher and Smeers 1984.
- Cournot Model, Mathiesen, Roland Thonstad 1987.
- Two level models with Downstream market power only: Egging, Gabriel, Holz and Zhuang 2008.
- Oligopoly of oligoplies: Boots, Rijkers and Hobbs 2003 (reformulated as single stage).
- Oligopoly of oligopolies: Holz, von Hirschhausen and Kemfert 2008.
- Stochastic perfect competition and Cournot: Abada, Gabriel, Massol 2012.

A modeling approach: bilateral negotiation models

Summing up what is coming

- (i) It is better (in fact optimal under market value pricing) to have mid-streamers with market power in the negotiation.
- (ii) There is no negotiation if mid-streamers have lost market power.
- (iii) Except for unlikely Allaz Vila contracts, there is no contract if there is no negotiation to counter upstream market power.
- (iv) The final result is then a Cournot or double marginalization model with significant loss of welfare.

Background

- Principle of the analysis:
  - The above models (that have been used in the literature to examine the impact of the elimination of the downstream market power) fully neglect the bargaining power of the mid-streamers with respect to the producers.
  - Gabraith (1952) introduced the idea of "countervailing power": strong buyers can get reduced prices from strong sellers.
  - This idea has been developed in different papers of the literature and has also been verified empirically. It provides the initial intuition of the work.
  - Riviere (2011) has looked at the bargaining power in the restructured EU gas market using concepts of cooperative games.
- We want to get a modeling approach that treats pairs of prices and quantities (as in contracts) using non cooperative games (Fontenay and Gans 2012 and preceding versions of the paper))

Fontenay and Gans Model for bilateral negotiations

- A sketch of Fontenay and Gans model applied to the gas market
  - A pair of producer and mid-streamer concludes a contract on quantities, given the quantities already contracted by the other pairs of producer and mid-streamer. The pair sells to the downstream market according to some pricing scheme. This gives a certain revenue.
  - Producer and mid-streamer then bargain to share this revenue.
  - They may not reach an agreement, and hence fail to conclude the contract.
  - The negotiation for contractual quantities continues between the other pairs of producers and mid-streamers (without the pair that failed to conclude the contract).
  - The process stops at an equilibrium of bilateral contracts with contractual quantities and revenue sharing satisfying the above properties.
- Less usual in the gas literature but reflecting the traditional market well.
  - Bilateral negotiation on quantities assuming an underlying market value pricing principle (TOP).
  - Sharing the revenue: set the basis price in the indexation clause
- Question: what does this paradigm give when applied on hub pricing?

Nash equilibrium of contractual quantities

Principle: a producer and a mid-streamer join to conclude a contract on a quantity that maximises the sum of their utilities, taking into account the quantities concluded by others pair of producers and mid-streamers. This gives a Nash Equilibrium of contractual quantities (the TOP quantities).

What is the mid-streamers utility? It depends on the pricing paradigm.

- The mid-streamer sells at market value: this is perfect price discrimination where the mid-streamer captures the whole willingness to pay.
- The mid-streamer sells at hub price: this is the usual monopoly or oligopoly pricing (price times quantity).

Implication: TOP quantities

Proposition: A Nash Equilibirum of bilateral contracts where gas is sold at market value is efficient (quantities are those of a perfectly competitive equilibrium: an old claim of the industry). But it is price discriminatory!

Proposition: A Nash Equilibrium of bilateral contracts where gas is sold at hub price is not efficient (quantities are those of a Cournot equilibrium). But it is not price discriminatory!

Bargaining for contract revenue or contract basis price ("rent sharing"!)

Bargaining on contractual revenue results in transfers from the mid-streamer to the producer such that:

- Players bargain by pair:

  the profit obtained from a bilateral contract is allocated to the participants of that bilateral contract.

- The profit from the contract is shared fairly

  in a pair bargaining each agent receives half the difference between the profit obtained by contracting and the profit obtained by breaking down negotiations

- Payoffs are feasible

  in a pair bargaining, each agent gets a better payoff by contracting with the other than by breaking negotiations.

Implication: bilateral negotiation in the traditional market.

Assume any producer can sell to any mid-streamer.

As stated before: Market value pricing implies welfare maximization.

A second property: The game is super- additive and the grand coalition will form; players will receive their Shapley-Myerson value (nobody will object to the transfer) (Myerson 1977). These will determine the basis prices of the contracted quantities

To sum up: Contracts will be concluded in the integrated market and welfare maximized.

Implication: bilateral negotiation in the restructured market (1).

Assume again that any producer can sell to any mid-streamer.

Because hub pricing is like monopoly/Cournot pricing in case of upstream market power,

> the game is not necessarily super-additive: externalities between contracts must be taken into account. Shapley-Myerson value is not directly applicable.

A generalization is needed

> to account for externalities between coalitions (Myerson, Navarro). It is also necessary to account for the fact that negotiation can break during rent sharing and that the contractual process may not extend to the integrated market.

Implication: bilateral negotiation in the restructured market (2)

A first property: Hub value pricing is not welfare maximizing and hence implies an overall loss of welfare compared to market value pricing.

A second property: Hub pricing implies a loss of super additivity and hence a loss of guarantee that the grand coalition will form. The equilibrium may end up on a segmented market (with some pairs not concluding contracts because they do not agree on the rent sharing). This is what the theory says and this is what one effectively observes in the numerical results)!!

To sum up: We have lost welfare and market integration. The outcome of the market is more delicate to analyze and depends on technical assumptions.

Case Study: unintended consequences of downstream restructuring in presence of upstream market power.

The method

- Construct a stylized (but well calibrated) model of the EU gas market and neglect details of short term operations (assume grid codes operate perfectly).
  - In the traditional market: suppose a geographically segmented downstream market, a single mid-streamer in each segment and no cross-border trade.
  - In the restructured market: suppose full success of the restructuring in the sense that
    - the downstream market is integrated geographically (gas lake) thanks to the grid codes;
    - the above mid-streamers are in competition, still have some market power but not much thanks to the application of competition law.
  - Keep the same upstream structure in traditional and restructured markets.
- Identify an economic paradigm that gives an adequate representation of the traditional market:
  - choose between ”oligopoly of monopolies” and bilateral negotiation to find the paradigm that best reflects upstream and downstream market power.
- Move to the restructured market with a question:
  - what if the only market power (or the bulk of it) is with the upstream?

Step 1: identify the economic paradigm that best represents the traditional market: informal analysis

- "Oligopoly of monopolies"
  - The model assumes that the mid-streamer has no bargaining power with respect to producers.
  - This does not reflect the negotiation process (first an agreement on quantities and then a discussion on the price clauses).
  - Only allows for linear prices (all quantities are sold at the same price) and all producers sell at the same price on a given market segment.
- Bilateral negotiations
  - Overcomes the above limitations of the Oligopoly of monopolies paradigm.
  - Finds both quantities and transfers from mid-streamers to producers and hence contractual quantities (stylized TOP) and prices (stylized indexation: basis price of the indexation clause).

Step 2: Identify the best representation of the traditional market: quantitative comparison

- Start with the three producers five market segments model,
  - take bilateral negotiation with market value pricing and oligopoly of monopolies as paradigms
  - compute final demand price and demand volume and compare with observation.
- Results :

	Market Value Pricing	Oligopoly of Oligopolies	2010 historic
Pipeline imports	277 bcm	105 bcm	roughly 270 bcm
Prices	4.98 \$/mmbtu (m)+ 1.6 \$/mmbtu (s)	11.45 \$/mmbtu	around 8 \$/mmbtu

("m" for marginal value of gas, "s" uplift accounting for the captured surplus)

Table: *The two paradigms in the traditional market*

Result of the reallocation of the rent.

- Suppose one believes in the bilateral model in the traditional market, then the allocation of the market among producers leads to results that reflect the market power of Russia in principle but overestimates its observed role compared to Norway (security of supply is the usual unformalized explanation of the phenomenon):

	Production	uplift
Russia	!!!190 bcm	1.32$/mmbtu
Norway	!!!.35 bcm	2.65$/mmbtu
Algeria	52 bcm	1.88$/mmbtu

Table: *The traditional market: market share and rent sharing*

Step 3: Qualitative analysis of the impact of restructuring on bilateral bargaining

- Suppose restructuring is fully successful
  - grid codes have fully integrated the downstream market,
  - market integration and some help from competition law have eliminated all/most of the market power of mid-streamers (but have not touched the upstream),
  - and thanks to downstream market integration gas is sold at a single price at the hub (oil linked prices are not longer moot).
- This is a limit/close to limit case of the negotiation problem when the number of mid-streamers increases:
  - the limit: mid-streamers have lost all market power;
    - there is no counterparty to the negotiation with the producers
    - and one ends up with a Cournot model of producers only.
  - Close to the limit: mid-streamers have retained some bargaining power:
    - the situation becomes complicated because the grand coalition does not necessarily form. One cannot numerically characterize the resulting equilibrium but one can get an intuition for what is happening.

Quantitative analysis of the restructured market (1).

- Suppose one believes in the bilateral model in the traditional market. Moving from this state to the Oligopoly of oligopolies in the gas lake (full success of restructuring with almost fully competitive downstream) implies:

	traditional MVP	New-OoO
Quantities	277 bcm	175 bcm
Producer Profits	23.9 bn	23.3 bn
Mid-streamer Profits	35.9bn	8.1bn
Consumer Surplus		20.5
European Surplus	35.9bn	28.6bn

Table: *The restructured market: Two paradigms*

Quantitative analysis of the restructured market (2).

- Suppose one believes in the Oligopoly of monopolies model in the traditional market (the common reasoning). Moving from this state to the Oligopoly of oligopolies in the gas lake (full success of restructuring as before) implies:

	Traditional OoO	New-OoO
Quantities	109 bcm	177 bcm
Producer Profits	13.8bn	23.3bn
Mid-streamer Profits	15.8bn	8.1bn
Consumer Surplus	8 bn	20.5bn
European Surplus	23.8bn	28.6bn

Table: *The restructured market: Two paradigms*

Conclusion

Conclusion (1)

- The traditional system.
  - The negotiation of long term contracts under the market value pricing principle led to an efficient gas market, irrespectively of market power. This required a redistribution (in upstream and downstream) to arrive at a fair allocation of the revenue among the different agents of the market.
  - Numerical simulation suggests that this system properly describes the traditional market.
- The outcome of bilateral negotiations in the restructured market is not promising.
  - Numerical work suggests a structural difficulty that depends on the upstream market power: the grand coalition does not form (the market does not integrate) and the outcome in terms of long term contracts cannot be characterized.
  - The theory suggests an explanation: the combination of the increase of the number of mid-streamers and of hub pricing in presence of upstream market power enhances the impact of externalities in bilateral contracts: we are in uncharted waters.

Conclusion (2)

- A Oligopoly of oligopoly model is used as a surrogate to assess the outcome of bilateral negotiations in the restructured system when mid-streamers market power has been sufficiently mitigated to make the outcome of the negotiation in terms of contracts uncertain. We find:
  - Total welfare drastically decreases compared to the traditional market,
  - the EU looses a lot and the mid-streamers loose almost everything;
  - producers barely gain, which may explain some of their diverging positions:
    - Some producers may think that keeping the long-term contracts as is offers the best guarantee against the loss with respect to the traditional model.
    - Other producers may think that the above strategy will fail because one is too far ahead in the process. Moving to spot indexed prices and taking advantage of market power is then the best strategy at this stage for a producer.
- How to remedy the situation is beyond the scope of this analysis.

Appendix: Mathematical formulations

Perfect competition (1): optimization formulation

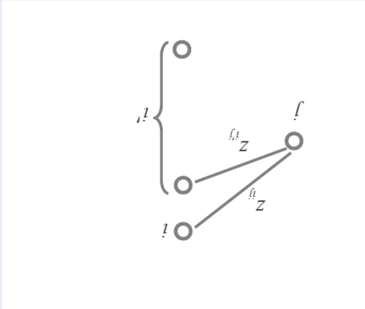
Wellfare maximization

$$\begin{aligned}
\text{Max} \; & \sum_j \int_0^{y_j} D_j(\xi_j) d\xi_j - \sum_i C_i(x_i) - \sum_{ij} e_{ij} z_{ij} - \sum_j \left[c_j(+m_j)\right] y_j \\
\text{s.t.} \; & \sum_j z_{ij} \leqq x_i \qquad && u_i \\
& -\sum_i z_{ij} \leqq -y_j \qquad && v_j \\
& z_{ij} \geqq 0
\end{aligned}$$

KKT conditions and netback interpretation

$$
\begin{aligned}
0 &\leqq v_j - D_j(y_j) && \perp y_j \geq 0 \\
0 &\leqq C_i'(x_i) - u_i && \perp x_i \geq 0 \\
0 &\leqq u_i + e_{ij} + c_j + (m_j) - v_j && \perp z_{ij} \geq 0 \\
0 &\leqq \sum_j z_{ij} - x_i && \perp u_i \geq 0 \\
0 &\leqq y_j - \sum_i z_{ij} && \perp v_j \geq 0
\end{aligned}
$$

Cournot competition



$$\min_{z_{ij}} D_j(z_{ij} + \sum_{i' \neq i} z_{i'j}) - C_i(z_{ij} + \sum_{j' \neq j} z_{ij'}) - (e_{ij} + c_j) z_{ij}$$

$$0 \leqq C_i'(z_{ij} + \sum_{j' \neq j} z_{ij'}) + e_{ij} + c_j + (m_j) - D_j(z_{ij} + \sum_{i' \neq i} z_{i'j}) - \frac{\partial D_j}{\partial z_{ij}}(z_{ij} + \sum_{i' \neq i} z_{i'j}) \perp z_{ij} \geq 0$$

Oligopoly of producers and monopolies of mid-streamer in a segmented downstream market (1)

Objective: make m_j (margin of downstream) endogenous)
<u>Traditional market</u> : one mid-streamer in each market segment.
Let p_j be the input price in j (a single border price $\neq$ reality)
The mid-streamer solves

$$\max_{y_j \geq 0} D_j(y_j)y_j - p_j y_j - c_j y_j$$

or

$$0 \leqq p_j + c_j - D_j(y_j) - D_j'(y_j)y_j \ \perp y_j \geq 0$$

Assume $y_j \geq 0$ (not a strong assumption)
then $p_j + c_j + D_j(y_j) - D_j'(y_j)y_j = 0$ defines a derived inverted demand $p_j(y_j)$

Oligopoly of producers and monopolies of Mid-Streamers in a segmented downstream market (2)

Traditional market: one mid-streamer at each market segment. Replace $D_j(y_j)$ by $p_j(y_j)$ in the Cournot model

$$\begin{aligned} 0 \leqq & C_i'(z_{ij} + \sum_{j' \neq j} z_{ij'}) + e_{ij} - p_j(z_{ij} + \sum_{i' \neq i} z_{i'j}) \\ & - \frac{\partial p_j}{\partial z_{ij}}(z_{ij} + \sum_{i' \neq i} z_{i'j}) \perp z_{ij} \geq 0 \end{aligned}$$

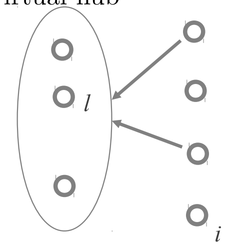
extension to an upstream oligopoly (or “double marginalisation”)

Oligopoly of producers and oligopolies of Mid-Streamers in an integrated downstream market (1)

Restructured market: Assume grid codes and competition law to

- reduce the number of market segments into a few virtual hubs
- increase the number of mid-streamers at each virtual hub

An extreme case: a single virtual hub



l now designates the mid-streamers in the virtual hub

Oligopoly of oligopolies in an integrated downstream market (2)

The downstream oligopoly á la Cournot: each mid-streamer solves

$$\max_{y_l \geq 0} D(y_l + \sum_{l' \neq l} y_{l'})y_l - p \cdot y_l - c_l y_l$$

where p is the single price on the hub.
or $0 \leqq p + c_l - D(\sum_l y_l) - D'(\sum_l y_l)y_l \perp y_l \geq 0$.
The limit case with many mid-streamers and $\sum_l y_l \geq 0$

$$p + c_l = D(\sum y_l)$$

and we end up with a standard Cournot model.

Nash equilibrium of contractual quantities (1)

Principle: a producer and a mid-streamer join to conclude a contract on a quantity z_{ij} that maximises the sum of their utilities, taking into account the quantities $z_{i'j'}$ concluded by others pair of producers and mid-streamers.

$$\max_{z_{ij} \geq 0} u_j(z_{ij} + \sum_{\substack{i' \neq i \\ j' \neq i}} z_{ij}) - C_i(z_{ij} + \sum_{j' \neq j} z_{ij'}) - e_{ij} z_{ij} - c_j z_{ij}$$

where u_l is the utility' function of the mid-streamer.

This gives a Nash Equilibrium of contracts.

Nash equilibrium of contractual quantities (2)

What is the mid-streamers utility $u_j(\sum_i z_{ij})$
Two pricing paradigms.

- The mid-streamer sells at market value:

$$u_j(\sum_i z_{ij}) = \int_0^{\sum_i z_{ij}} D_j(\xi) d\xi :$$

  this is perfect price discrimination where the mid-streamer captures the whole willingness to pay.

- The mid-streamer sells at hub price:

$$u_j(\sum_i z_{ij}) = D_j(\sum_i z_{ij}) z_{ij}$$

  this is the usual monopoly or oligopoly pricing.

Implications (1)

Suppose a Nash equilibrium of bilateral contracts where gas is sold at market value.

The equilibrium Conditions:

$$0 \leqq c_i'(z_{ij} + \sum_{j' \neq j} z_{ij}) + e_{ij} + c_j - D_j(z_{ij} + \sum_{i' \neq i} z_{ij}) \perp z_{ij} \geq 0$$

are those of of perfect competition.

Proposition: A Nash Equilibirum of bilateral contracts where gas is sold at market value is efficient (an old claim of the industry).

Note: but it is discriminatory!

Implications (2)

Suppose a Nash equilibrium of bilateral contracts where gas is sold at hub price.

The equilibrium conditions:

$$
\begin{aligned}
0 \leq & c_i'(z_{ij} + \sum_{j' \neq j} z_{ij}) + e_{ij} + c_j - D_j(z_{ij} + \sum_{i' \neq i} z_{ij}) \\
& - D_j'(z_{ij} + \sum_{i' \neq i} z_{ij}) z_{ij} \quad \perp z_{ij} \geq 0
\end{aligned}
$$

are those of Cournot competition.

Proposition: A Nash Equilibirum of bilateral contracts where gas is sold at hub price is not efficient.

(Note: but it is also not discriminatory!)

Bargaining for contract revenue (”rent sharing”!) (1)

Bargaining on contractual revenues results in transfers t_{ij} from the mid-streamer to the producer (the *Take or Pay* contract) such that:

- The net position of the mid-streamer j is

$$\phi_j = \int_0^{\sum_{i'} z_{i'j}} D_j(\xi)d\xi - \sum_{i'} t_{i'j} \qquad \text{for market value pricing}$$

$$\phi_j = D_j(\sum_{i'} z_{i'j}) \sum_{i'} y_{i'j} - \sum_{i'} t_{i'j} \qquad \text{for hub pricing}$$

- The net position of the producer i is

$$\phi_i = \sum_{j'} t_{ij'} - C_i(\sum_{j'} z_{ij'})$$

Bargaining for contract revenue (”rent sharing”!) (2)

- Players bargain by pair:
  the profit obtained from a bilateral contract is allocated to the participants of that bilateral contract.

- The profit from the contract is shared fairly
  in a pair bargaining, each agent receives half the difference between the profit obtained by contracting and the profit obtained by breaking down negotiations

- Payoffs are feasible
  in a pair bargaining, each agent gets a better payoff by contracting with the other than by breaking negotiations.

Bilateral negotiation in the traditional market

Assume the (bipartite) graph is complete: any producer can sell to any mid-streamer.

A first property: Market value pricing implies welfare maximization.

A second property: Let transfers be such that each player receives its Shapley value
One can show that the game is supper- additive: if A and B have nul intersection

$$v(A \cup B) \geqq v(A) + v(B)$$

Then the grand coalition will form, players will receive their Shapley value (nobody will object to the transfer) (Myerson 1977).

To sum up: Contracts will be concluded and welfare maximized.

Bilateral negotiation in the restructured market (1)

Assume again that the graph is complete: any producer can sell to any mid-streamer

Because Hub pricing is is like monopoly pricing in case of upstream market power,

> the game is not necessarily supper-additive: a player may object to the transfer and break negotiation. Shapley value will not necessarily give a valid set of transfers

A more general concept: Meyerson value:

> accounts for the fact that not anybody negotiate with anybody / generalized Meyerson account for externalities between coalitions (the payoff of one coalition depends on what other coalitions have already done) (Fontenay and Gans 2007)

Bilateral negotiation in the restructured market (2)

Assume the (bipartite) graph is complete: any producer can sell to any mid-streamer.

A first property: Hub value pricing is not welfare maximizing and hence implies an overall loss of welfare compared to market value pricing.

A second property: Hub pricing implies a loss of super additivity and hence a loss of the guarantee of the grand coalition. The equilibrium may end up on a segmented market (with some pairs not concluding contracts because they do not agree on the rent sharing (and we effectively observe this phenomenon in the numerical results)!!

To sum up: We have a loss of welfare; the outcome in terms of contractual equilibrium is much more delicate to analyze and depend on technical assumptions.

Are payoffs always feasible: a numerical Experiment?

—P—	—M—	producers payoff	mid-streamers payoff	infeasible
1	2	12.75	2.625	
1	3	13.359	0.609	
1	4	13.28	-0.08	x
2	1	3.375	13.5	
2	3	4.866	1.819	
2	4	4.752	0.864	x
3	1	1.688	15.187	
3	2	1.875	6.187	
3	3	3.122	1.941	x
4	1	1.013	16.2	
5	1	0.675	16.675	
6	1	0.482	17.357	
7	1	0.362	17.719	

What if one increases the number of mid-streamers: 1 producer 1 mid-streamer

In case of a breakdown in negociations between p and m, $G \backslash pm = (P \cup M, \emptyset)$. Hence, both will have 0 profit.

$$\begin{aligned} -aq_{1,1} + b - a(q_{1,1}) - c &= 0 \\ (b - a(q_{1,1}))q_{1,1} - t_{1,1} &= t_{1,1} - c(q_{1,1}) \\ (b - a(q_{1,1}))q_{1,1} - t_{1,1} &\geq 0 \\ t_{1,1} - c(q_{1,1}) &\geq 0 \end{aligned}$$

which yields: $q_{1,1} = \frac{b-c}{2a}$, $t_{1,1} = -\frac{3c^2-2bc-b^2}{8a}$ and $\Pi^p = \Pi^m = \frac{(b-c)^2}{8a}$.

What if one increases the number of mid-streamers: 1 producer 2 mid-streamers

In case of a breakdown in negociations between p and m_1, $G\backslash pm_1 = (P \cup M, \{pm_2\})$. Hence, m_1 will have 0 profit and p will get $\Pi^p_{p,m_1} = \frac{(b-c)^2}{8a} = \Pi^p_{p,m_2}$.

$$-aq_{1,1} + b - a(q_{1,1} + q_{1,2}) - c = 0$$

$$-aq_{1,2} + b - a(q_{1,1} + q_{1,2}) - c = 0$$

$$(b - a(q_{1,1} + q_{1,2}))q_{1,1} - t_{1,1} = t_{1,1} + t_{2,1} - c(q_{1,1} + q_{1,2}) - \frac{(b-c)^2}{8a}$$

$$(b - a(q_{1,1} + q_{1,2}))q_{1,2} - t_{2,1} = t_{1,1} + t_{2,1} - c(q_{1,1} + q_{1,2}) - \frac{(b-c)^2}{8a}$$

$$(b - a(q_{1,1} + q_{1,2}))q_{1,1} - t_{1,1} \geq 0$$

$$(b - a(q_{1,1} + q_{1,2}))q_{1,2} - t_{2,1} \geq 0$$

$$t_{1,1} + t_{2,1} - c(q_{1,1} + q_{1,2}) \geq \frac{(b-c)^2}{8a}$$

which yields: $q_{1,1} = q_{1,2} = \frac{b-c}{3a}$, $t_{1,1} = t_{2,1} = \frac{(b-c)(55c+17b)}{216a}$, $\Pi^p = 17\frac{(b-c)^2}{108a}$ and

What if one increases the number of mid-streamers: 1 producer 3 mid-streamer

In case of a breakdown in negociations between p and m_1, $G \backslash pm_1 = (P \cup M, \{pm_2, pm_3\})$.
Hence, m_1 will have 0 profit and p will get $\Pi^p_{p,m_1} = 17\frac{(b-c)^2}{108a} = \Pi^p_{p,m_2} = \Pi^p_{p,m_3}$.

$$- aq_{1,1} + b - a(q_{1,1} + q_{1,2} + q_{1,3}) - c = 0$$
$$- aq_{1,2} + b - a(q_{1,1} + q_{1,2} + q_{1,3}) - c = 0$$
$$- aq_{1,3} + b - a(q_{1,1} + q_{1,2} + q_{1,3}) - c = 0$$
$$(b - a(q_{1,1} + q_{1,2} + q_{1,3}))q_{1,1} - t_{1,1} = t_{1,1} + t_{2,1} + t_{3,1} - c(q_{1,1} + q_{1,2} + q_{1,3}) - \frac{17(b-c)^2}{108a}$$
$$(b - a(q_{1,1} + q_{1,2} + q_{1,3}))q_{1,2} - t_{2,1} = t_{1,1} + t_{2,1} + t_{3,1} - c(q_{1,1} + q_{1,2} + q_{1,3}) - \frac{17(b-c)^2}{108a}$$
$$(b - a(q_{1,1} + q_{1,2} + q_{1,3}))q_{1,3} - t_{3,1} = t_{1,1} + t_{2,1} + t_{3,1} - c(q_{1,1} + q_{1,2} + q_{1,3}) - \frac{17(b-c)^2}{108a}$$
$$(b - a(q_{1,1} + q_{1,2} + q_{1,3}))q_{1,1} - t_{1,1} \geq 0$$
$$(b - a(q_{1,1} + q_{1,2} + q_{1,3}))q_{1,2} - t_{2,1} \geq 0$$
$$(b - a(q_{1,1} + q_{1,2} + q_{1,3}))q_{1,2} - t_{3,1} \geq 0$$
$$t_{1,1} + t_{2,1} + t_{3,1} - c(q_{1,1} + q_{1,2} + q_{1,3}) \geq \frac{17(b-c)^2}{108a}$$

which yields: $q_{1,1} = q_{1,2} = \frac{b-c}{4a}$, $t_{1,1} = t_{2,1} = t_{3,1} = \frac{(b-c)(337c+95b)}{1728a}$, $\Pi^p = 95\frac{(b-c)^2}{576a}$ and $\Pi^m = 13\frac{(b-c)^2}{}$

What if one increases the number of mid-streamers: 1 producer 4 mid-streamer

In case of a breakdown in negociations between p and m_1, $G\backslash pm_1 = (P \cup M, \{pm_2, pm_3, pm_3\})$.
Hence, m_1 will have 0 profit and p will get $\Pi^p_{p,m_1} = 95\frac{(b-c)^2}{576a} = \Pi^p_{p,m_2}\Pi^p_{p,m_3} = \Pi^p_{p,m_4}$.

$-aq_{1,1} + b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}) - c = 0$

$-aq_{1,2} + b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}) - c = 0$

$-aq_{1,3} + b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}) - c = 0$

$-aq_{1,4} + b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}) - c = 0$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,1} - t_{1,1} \geq 0$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,1} - t_{1,1} =$
$t_{1,1} + t_{2,1} + t_{3,1} + t_{4,1} - c(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4})$
$95(b-c)^2/(276a)$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,2} - t_{2,1} =$
$t_{2,1} + t_{2,1} + t_{3,1} + t_{4,1} - c(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4})$
$-95(b-c)^2/(576a)$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,3} - t_{3,1} =$
$t_{3,1} + t_{2,1} + t_{3,1} + t_{4,1} - c(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4})$
$-95(b-c)^2/(576a)$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,4} - t_{4,1} =$
$t_{4,1} + t_{2,1} + t_{3,1} + t_{4,1} - c(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4})$
$-95(b-c)^2/(576a)$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,2} - t_{2,1} \geq 0$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,3} - t_{3,1} \geq 0$

$(b - a(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}))q_{1,4} - t_{4,1} \geq 0$

$t_{1,1} + t_{2,1} + t_{31,1} + t_{4,1} - c(q_{1,1} + q_{1,2} + q_{1,3} + q_{1,4}) \geq$
$95(b-c)^2/(576a)$

Solving the first 4 equations (pairwise profit maximization) yields: $q_{1,1} = q_{1,2} = q_{1,3} = q_{1,4} = \frac{b-c}{5a}$.
Substituting in the next 4 equations (fairness) yields: $t_{1,1} = t_{2,1} = t_{3,1} = t_{4,1} = \frac{(b-c)(11449c+2951b)}{72000a}$.

The producer profit is $\Pi^p = 2951\frac{(b-c)^2}{18000a}$. The mid-streamer profit is $\Pi^m = -71\frac{(b-c)^2}{72000a}$. **The mid-streamers profits can never be positive in this case and the producer profit is always less than the one obtained**